

**A29****NEMA NU 2012 Performance Evaluation of Silicon-Photomultiplier-Based and conventional PMT-based Time-of-Flight systems**

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The aim of this study is to assess the performance characteristic of new-generation SiPM-based and conventional PMT-based time-of-flight PET systems. For this purpose, NEMA NU 2-2012 performance measurements for characterizing spatial resolution (SR), sensitivity, image quality (IQ), noise equivalent count rate (NECR) and linearity were performed on GE Signa integrated PET/MR Discovery MI PET/CT (DMI) and Biograph mCT Flow PET/CT (Biograph).

**METHODS:**

NEMA NU-2 2012 testing was performed independently on GE Signa integrated PET/MR, installed at Katholieke Universiteit Leuven and the others at Ghent University. For the SR measurements, a <sup>18</sup>F-FDG point source inside a glass capillary tube was positioned at 1 and 10 cm off-center in the field of view. Sensitivity tests at both institutions, plastic tubing (70 cm in length, 1 mm in inner diameter) was filled with an averaged calibrated activity of approximately 20.0 MBq of <sup>18</sup>F-FDG. The line source was placed in an aluminum sleeve ensuring complete annihilation of all positrons. NECR were measured using a 70-cm-long polyethylene cylinder with a diameter of 20 cm and a line source inserted axially into the cylinder 4.5 cm off-centered filled with 871.0, 883.0 and 865.0 MBq of <sup>18</sup>F-FDG (at first frame start) for all systems. PET image quality tests were evaluated using the NEMA IQ phantom with a 4:1 ratio for the hot sphere to background activity concentration, which equals 52.0 MBq for a 9800 ml phantom. The scatter phantom line source was filled with activity between 116 – 120 MBq at scan start. For all systems, the accuracy of the attenuation and scatter correction were determined from the uniform background and could lung insert regions.

**RESULTS:**

The contrast recovery for small spheres is better for the Discovery MI 4 rings than for any of the other commercially available systems in Table 1. This better contrast recovery should lead to an improvement in the system's ability to detect, visualize, and quantify smaller lesions.

Table 2 summarizes important counting rate metrics measured at both UGhent and KU Leuven.

The spatial resolution testing showed that, taken as a whole over all 3 resolution directions and the different distances from the center of the FOV, the Discovery MI performs comparably to the other systems in Table 1. The sensitivity of the Discovery MI is the highest of all the PET/CT systems although still lower than that of the GE Signa PET/MR system, with longer PET axial FOVs and smaller transaxial FOVs.

**CONCLUSION:**

NEMA NU-2 2012 testing of the SiPM-based Discovery PET/CT systems points to improved diagnostic sensitivity for small lesions and a wide range of promising applications, from low-dose oncology studies to high-dose studies with short-lived isotopes. However, sensitivity and counting rate measurements were substantial different as compared to GE Signa PET/MR system, with longer PET axial FOVs and smaller transaxial FOVs. In addition, comparisons with other PET/CT systems demonstrate the substantial performance improvements possible with the new generation of SiPM-based TOF PET/CT systems.

**Table 1 (abstract A29).** Shows the image quality, spatial resolution and sensitivity results for both institutions

Parameter	GE Healthcare			Siemens Healthcare
	Discovery MI PET/CT 3 Rings	Discovery MI PET/CT 4 Rings	SIGNA PET/MR	Biograph mCT Flow PET/CT
Contrast Recovery [%]				
10 mm–Radioactive	44.2	53.7	48.7	28.5
13 mm–Radioactive	53.4	64.0	62.9	42.3
17 mm–Radioactive	66.4	73.1	68.1	58.4
22 mm–Radioactive	70.7	82.7	76.1	70.7
28 mm–Non-Radioactive	81.6	86.8	87.1	72.1
37 mm–Non-Radioactive	84.5	90.7	92.7	78.3
Lung Error [%]	7.8	4.4	1.6	5.6
Spatial Resolution FWHM*				
Radial, 1 cm	4.65	4.10	4.46	4.33
Axial, 1 cm	4.47	4.48	5.35	4.25
Tangential, 1 cm	4.36	4.19	4.08	4.33
Radial, 10 cm	5.54	5.47	5.81	5.16
Axial, 10 cm	5.44	6.01	6.75	5.85
Tangential, 10 cm	4.75	4.49	4.44	4.72
Radial, 20 cm	7.41	7.53	8.42	5.55
Axial, 20 cm	5.78	6.10	7.30	7.80
Tangential, 20 cm	5.18	4.90	5.27	6.48
Sensitivity – Center of FOV (cps/kBq)	7.26	13.7	22.9	9.60

\*Filtered backprojection

**Table 2 (abstract A29).** Counting Rate Measurements

Type of measurement *	GE Healthcare			Siemens Healthcare
	Discovery MI PET/CT 3 Rings	Discovery MI PET/CT 4 Rings	SIGNA PET/MR	Biograph mCT Flow PET/CT
Scatter Fraction at Peak NECR	41.7 %	40.4 %	43.4 %	33.5 %
Peak NECR	102.7 kcps	201.1 kcps	216.8 kcps	185 kcps
Activity at Peak NECR	24.70 kBq/ml	22.1 kBq/ml	18.6 kBq/ml	29.0 kBq/ml
Maximum Absolute Error	3.19 %	3.86 %	2.92 %	3.7 %

\* <sup>18</sup>F-FDG PET imaging